System Operational Effectiveness:
Enhancing Reliability and Reducing the Logistics Footprint

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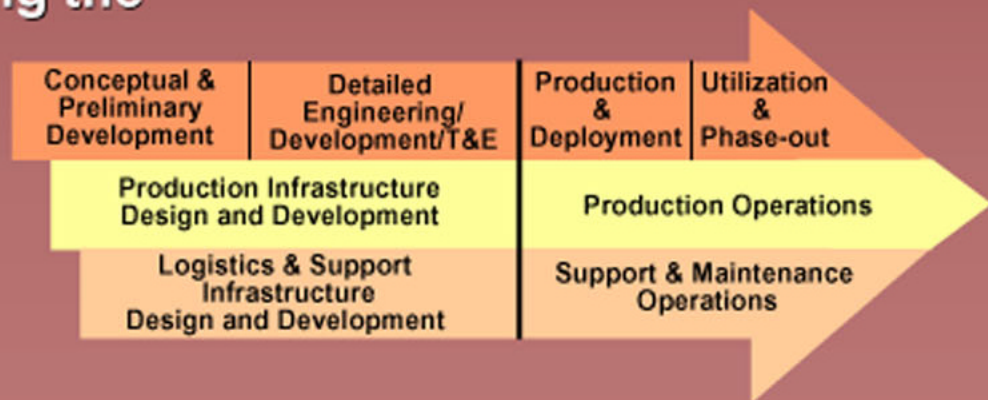Stevens Institute of Technology
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STEVENS
Institute of Technology

Systems and Supportability Engineering:
Dependency and Desired Integration

- The desire and the lexicon/literature has supported this integration for decades… COTS-based system acquisition mandates it!

- The imperative to reduce system operating and support costs is even more urgent today… supportability and logistics have a significant role to play in realizing this.

- Accordingly it is essential to clear the haze surrounding the domain/ scope of supportability and logistics…

- Understanding the domain and scope of supportability and logistics facilitates leveraging the intuitive "cause and effect" relationship between system design and system support… and ultimately system affordability.

Conceptual & Preliminary Development	Detailed Engineering/ Development/T&E	Production & Deployment	Utilization & Phase-out
Production Infrastructure Design and Development		Production Operations	
Logistics & Support Infrastructure Design and Development		Support & Maintenance Operations	

Evolution of System Architecting Paradigms:
In a Complex Information Intensive System Context

Past	Present	Future

Present: 75% COTS · 5:1 Reduction in Cost · 100X Increase in Throughput

Past
- Mil-Spec Hardware and Software for Computing Infrastructure
- Closed/Proprietary Architecture/ Interfaces
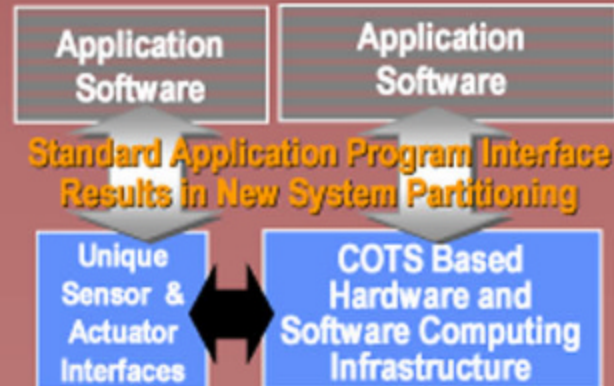- Mission Capabilities Created By the Combination of Unique Software and Hardware

Present
- Commercially Available Technologies for Computing Infrastructure
- Open Architecture Using Commercial Standards for Interfaces
- Mission Capabilities Created By Reliable, Dependable, Durable Software Applications

Future
- Extend Open Standards to Focus on System of Systems Interoperability (Network -Centric)
- Utilize High Throughput of Commercial Technologies
- "Smart" Software

Past diagram: Unique Software / Tightly Linked Proprietary Interface / Unique Hardware

Present diagram: Application Software · Application Software · Standard Application Program Interface Results in New System Partitioning · Unique Sensor & Actuator Interfaces ⬌ COTS Based Hardware and Software Computing Infrastructure

A Complex System - Multiple Partner Team
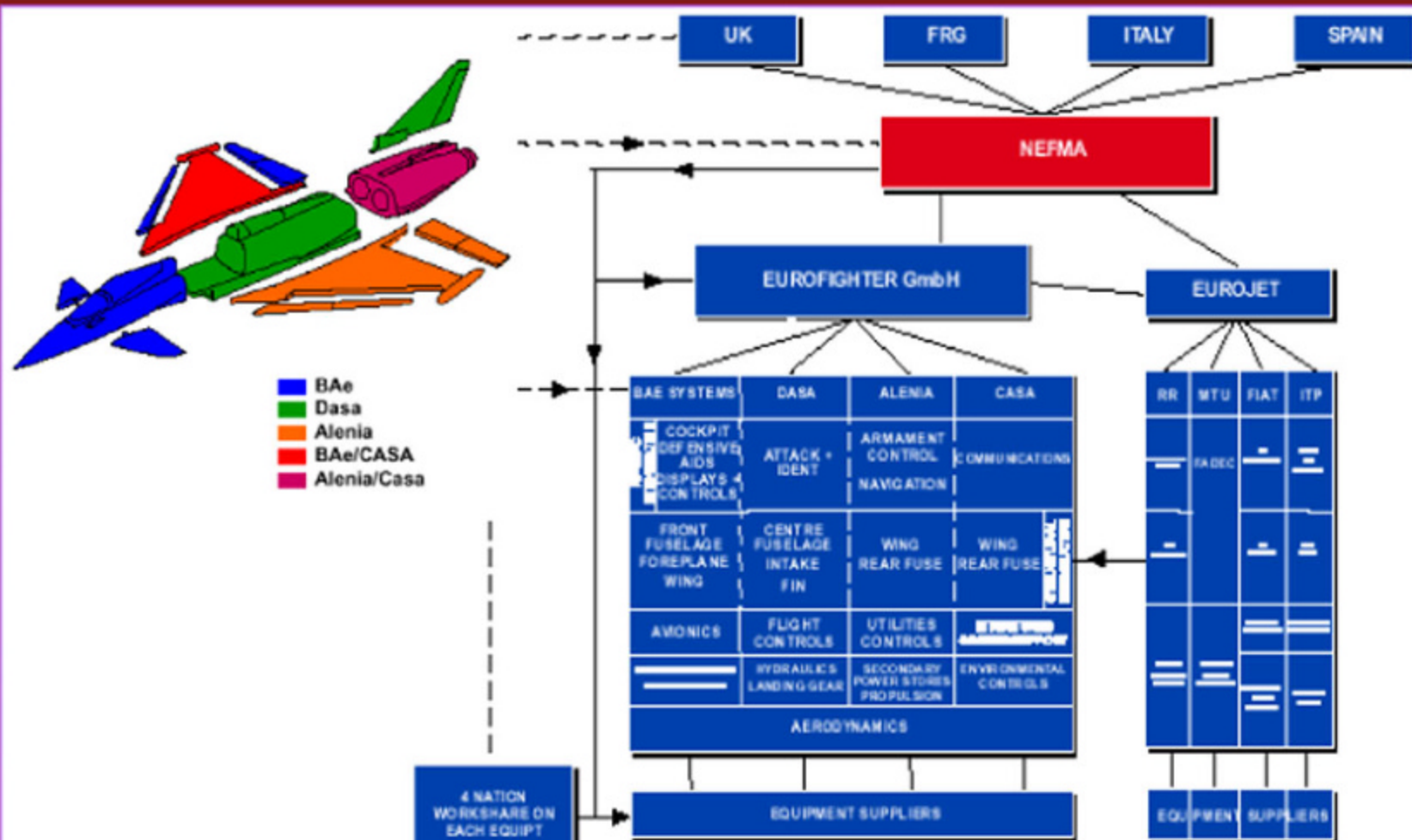
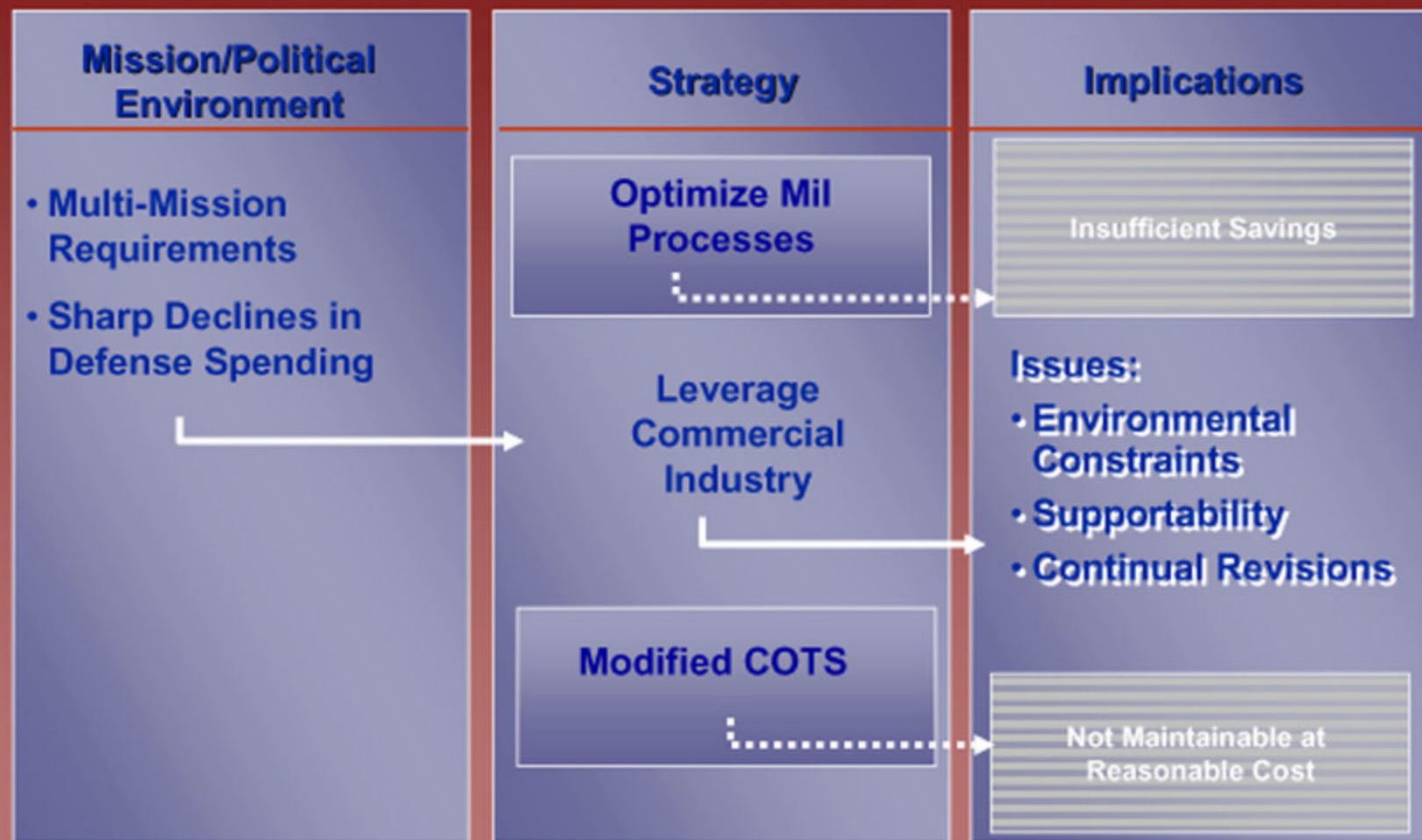EUROFIGHTER - A COMPLEX MANAGEMENT TASK WITH
- MULTIPLE INTERFACES
- CUSTOMER WORKSHARE REQUIREMENTS
- DIFFERING NATIONAL PROCUREMENT RULES
- INTERNATIONAL AND NATIONAL LINKS

22 March 2000

Transition to Commercial Technology

Mission/Political Environment	Strategy	Implications

Mission/Political Environment

- Multi-Mission Requirements
- Sharp Declines in Defense Spending

Strategy

Optimize Mil Processes

Leverage Commercial Industry

Modified COTS

Implications

Insufficient Savings

Issues:
- Environmental Constraints
- Supportability
- Continual Revisions

Not Maintainable at Reasonable Cost

Transition to Commercial Technology:
Need to Address Changing Physical Baselines

Reference Configuration

BF-A · AP-A
BF-A · AP-A
BF-A · AP-A
BF-B · AP-A
BF-B · AP-B
BF-B · AP-B
BF-B · AP-B
BF-B · AP-B
· AP-B
· AP-B
· AP-B

Total 19 Chassis

'98 Technology Update

BF-A · AP-C
BF-A · AP-C
BF-A · AP-C
BF-B · AP-C
BF-B · AP-D
BF-B · AP-D
BF-B · AP-D
BF-B

Total 15 Chassis

'00 Technology Update

BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP

Total 7 Chassis

Technology Refresh

BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP
BF/SP · IP

Total 7 Chassis

Processing Summary	Processing Summary	Processing Summary	Processing Summary
1995-Level Technology	1998-Level Technology	2000-Level Technology	2003-Level Technology
8 Beamformers - 75 GOPS	8 Beamformers - 75 GOPS	6 BF/Signal Processors - 240 GOPS	6 Beamformers - 380 GOPS
11 Allocatable Processors - 65 GOPS	7 Allocatable Processors - 75 GOPS	2 Information Processors - 30 GOPS	2 Information Processors - 50 GOPS
Total Throughput - **140 GOPS**	Total Throughput - **150 GOPS**	Total Throughput - **270 GOPS**	Total Throughput - **430 GOPS**

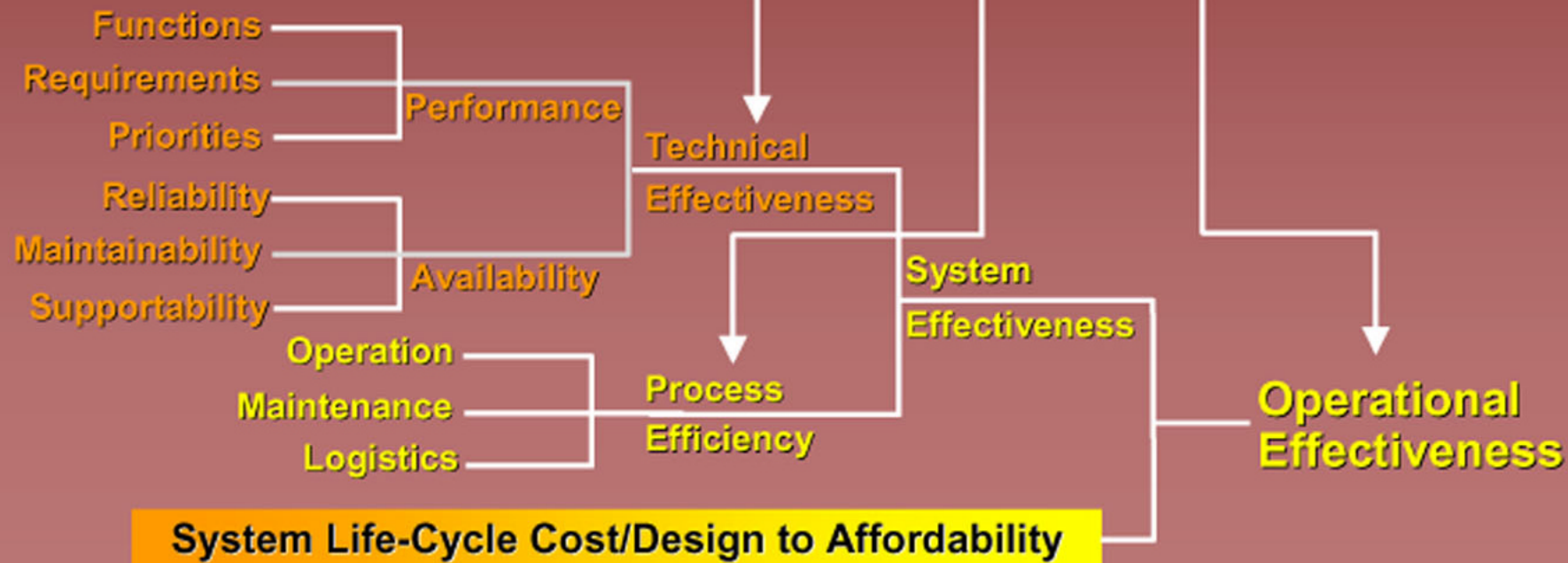# System Operational Effectiveness
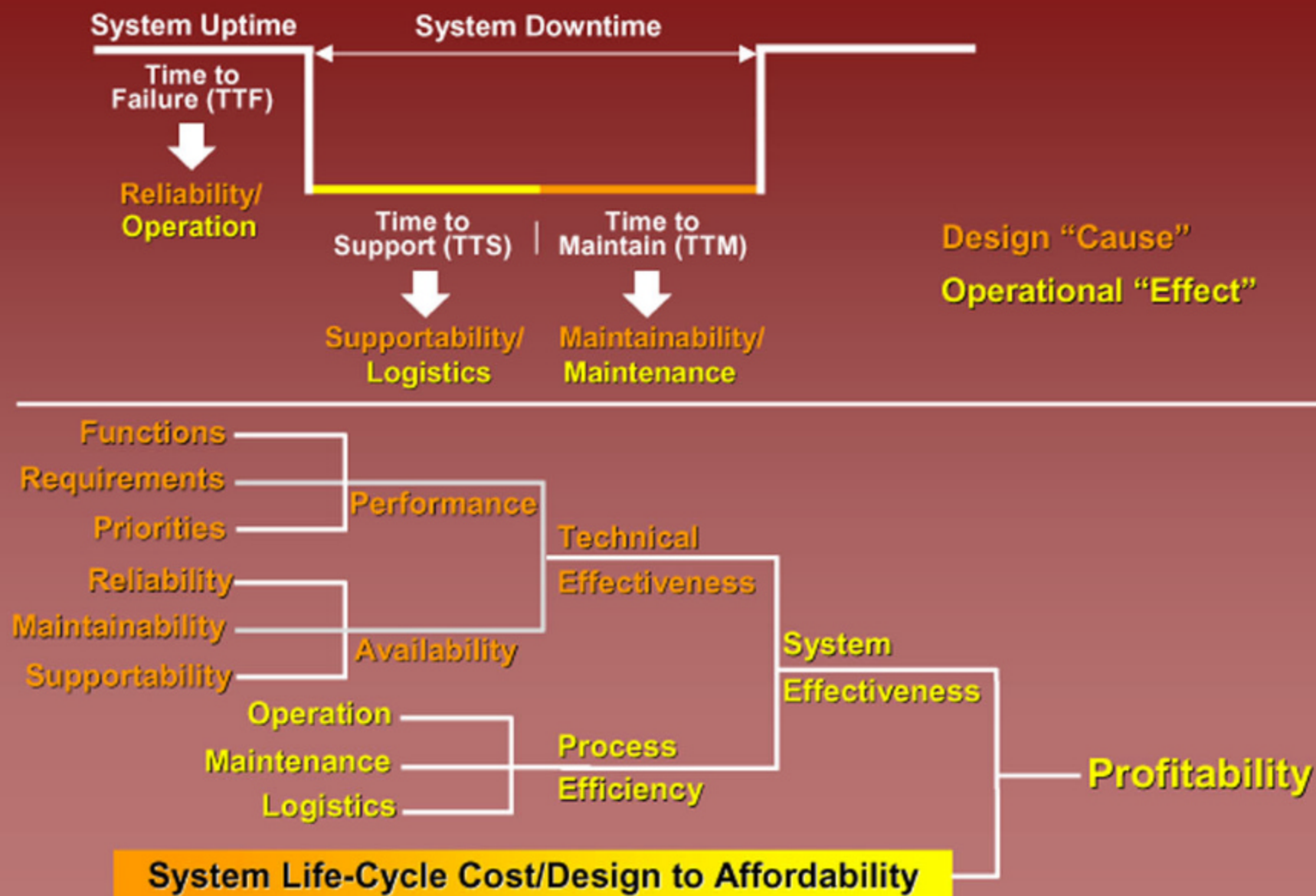
System Operational Effectiveness

A System Integrator's Charter

Manage and Guarantee

Functions
Requirements
Priorities

Performance

Reliability
Maintainability
Supportability

Availability

Technical
Effectiveness

Operation
Maintenance
Logistics

Process
Efficiency

System
Effectiveness

Operational
Effectiveness

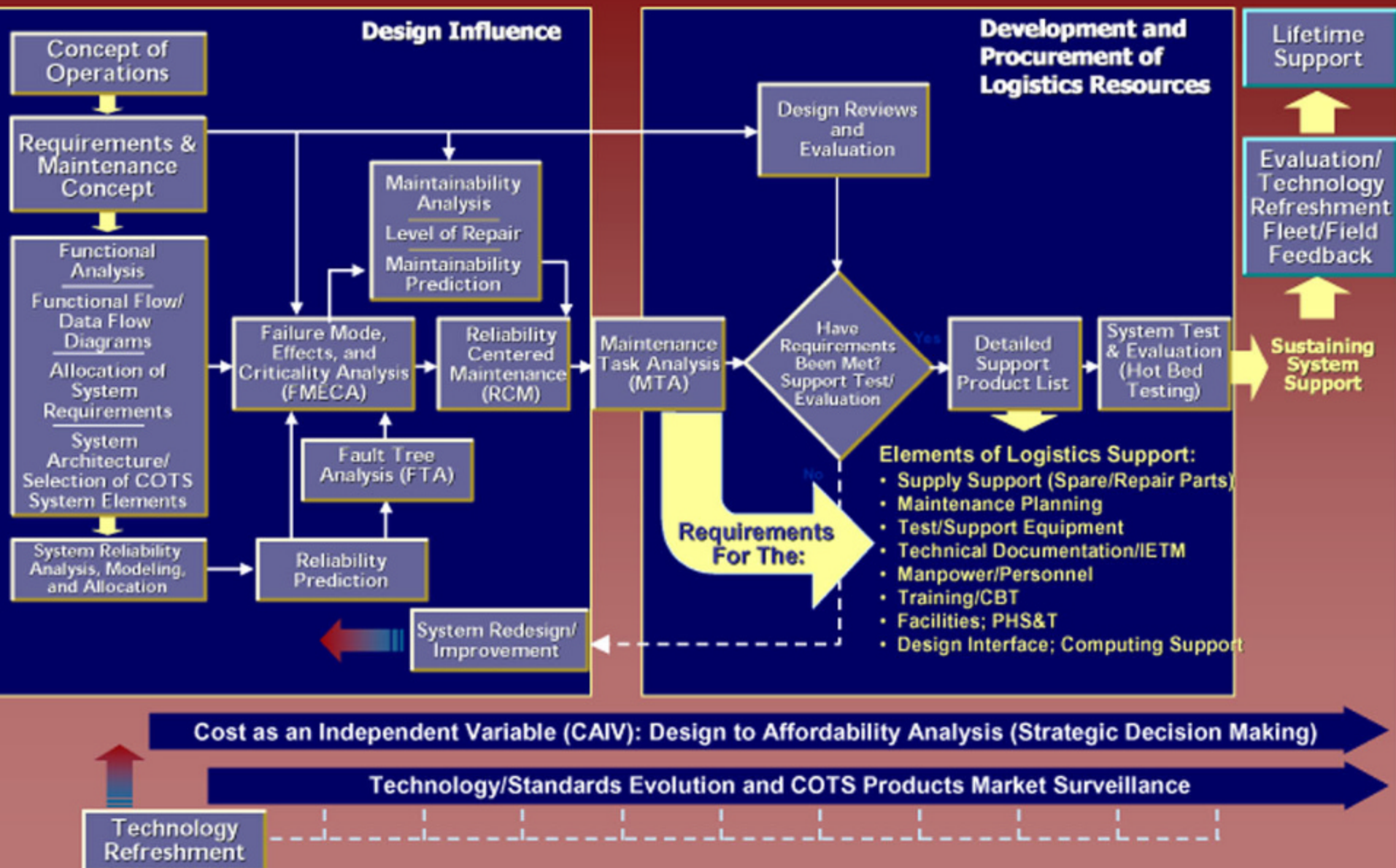**System Life-Cycle Cost/Design to Affordability**
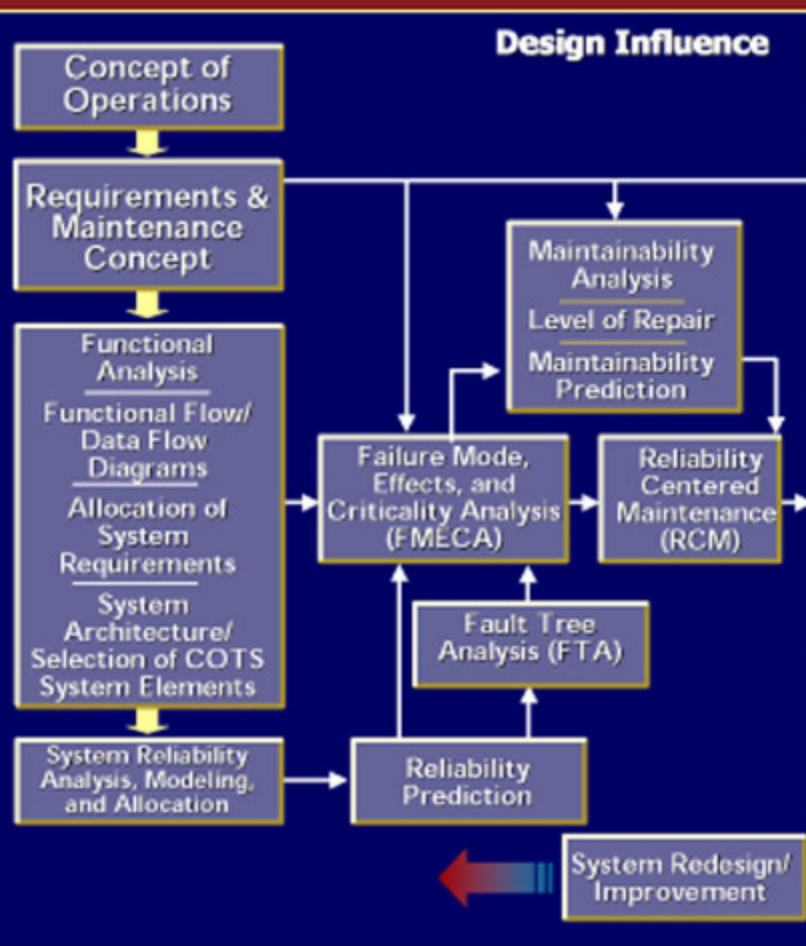
Systems Engineering & System Support:
A "Cause-and-Effect" Dependency
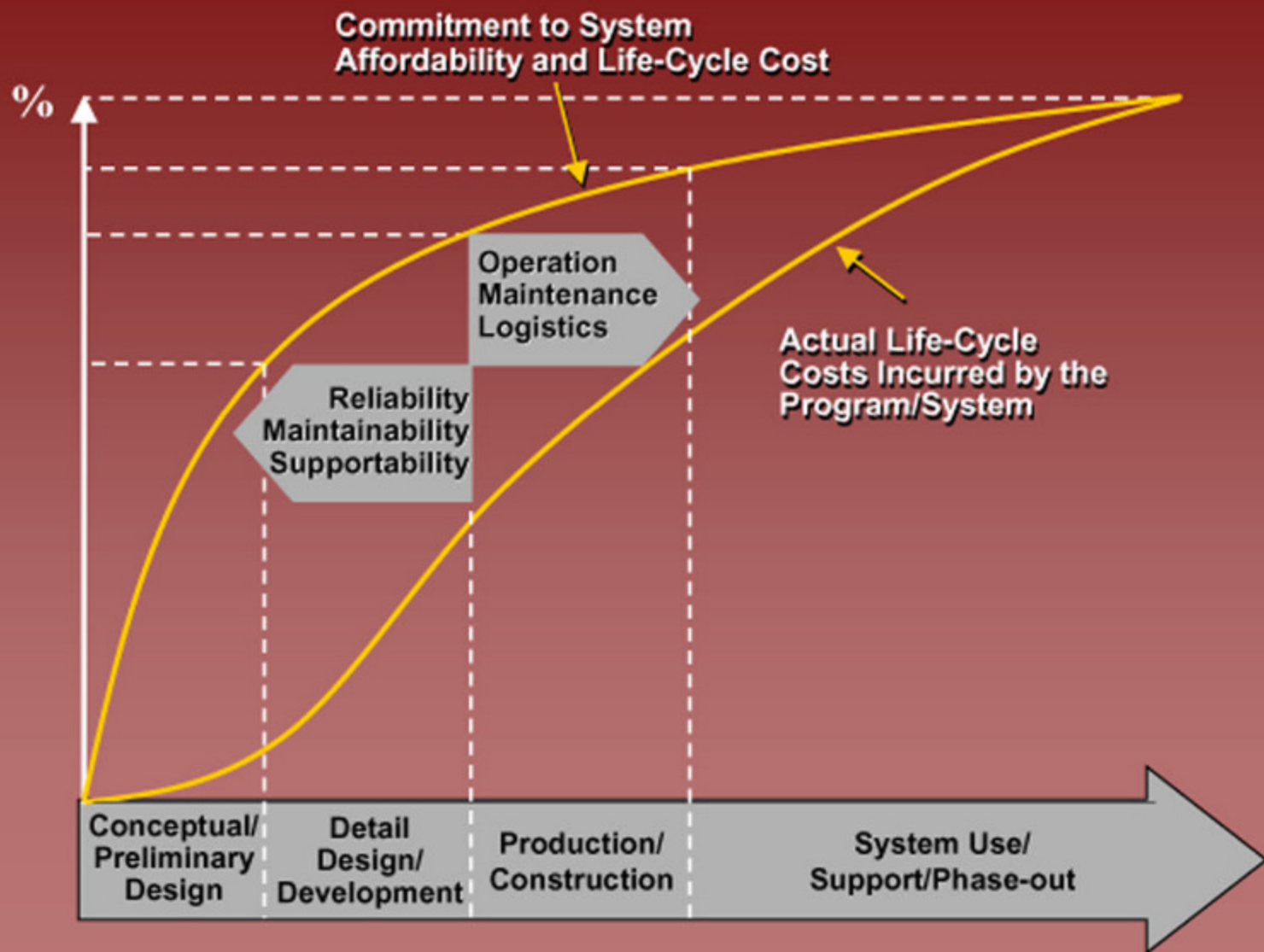
Reliability, Maintainability, and Supportability Engineering Process

Reliability, Maintainability, and Supportability Engineering Process

Design Influence

Concept of Operations

Requirements & Maintenance Concept

Functional Analysis
Functional Flow/ Data Flow Diagrams
Allocation of System Requirements
System Architecture/ Selection of COTS System Elements

Maintainability Analysis
Level of Repair
Maintainability Prediction

Failure Mode, Effects, and Criticality Analysis (FMECA)

Reliability Centered Maintenance (RCM)

Fault Tree Analysis (FTA)

System Reliability Analysis, Modeling, and Allocation

Reliability Prediction

System Redesign/ Improvement

Cost as an Independent Variable (C...

Technology/Standa...

Technology Refreshment

Reliability Tasks:
- Concept of Operation Definition/Mission Profile/Design Reference Mission
- Reliability Requirements Analysis and Allocation
- Reliability Modeling and Analysis
- Reliability Prediction
- Failure Mode, Effects, and Criticality Analysis
- Fault Tree Analysis

Reliability
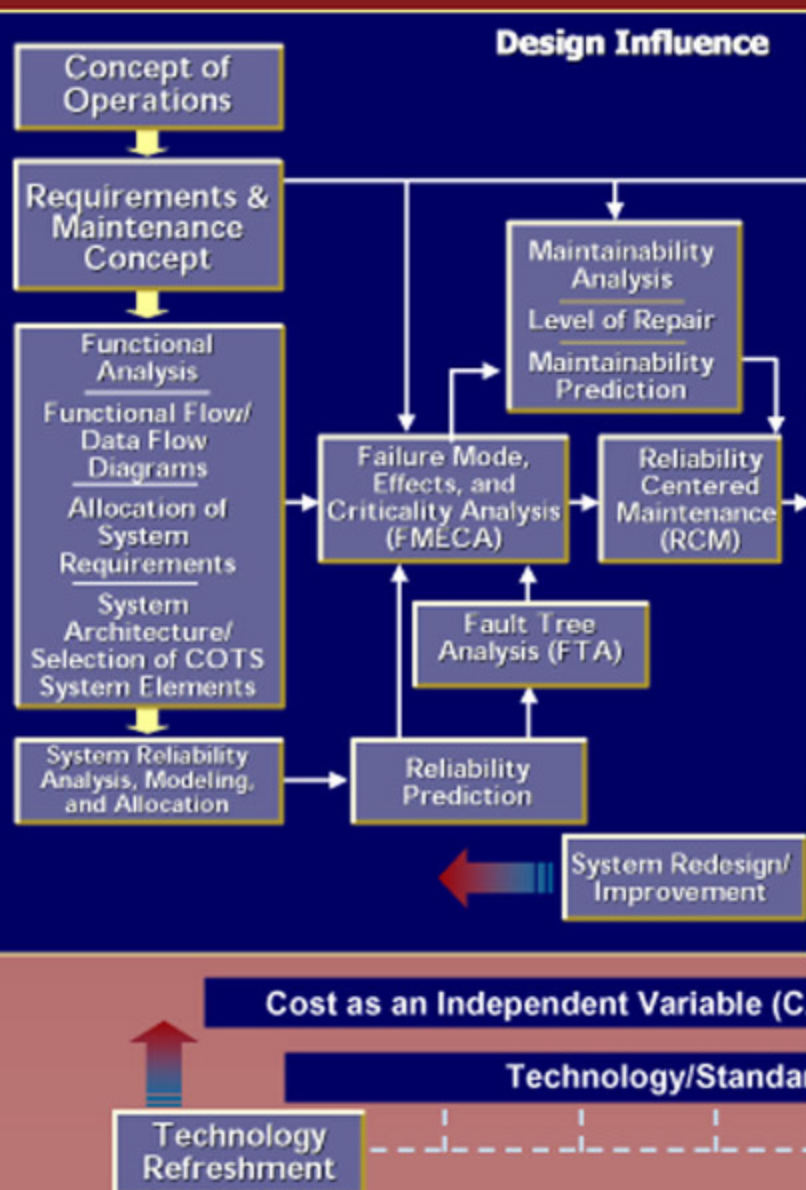
Maintainability

Supportability

- Redundancy
- Reconfigurability
- De-Rating
- System Criticality Assessment
  – Single Points of Failure
  – Degraded Modes of Operation
- Metrics
- Tools

Reliability, Maintainability, and Supportability Engineering Process

Design Influence

- Concept of Operations
- Requirements & Maintenance Concept
- Functional Analysis
  - Functional Flow/ Data Flow Diagrams
  - Allocation of System Requirements
  - System Architecture/ Selection of COTS System Elements
- Maintainability Analysis
  - Level of Repair
  - Maintainability Prediction
- Failure Mode, Effects, and Criticality Analysis (FMECA)
- Reliability Centered Maintenance (RCM)
- Fault Tree Analysis (FTA)
- System Reliability Analysis, Modeling, and Allocation
- Reliability Prediction
- System Redesign/ Improvement

Cost as an Independent Variable (C.

Technology/Standar

Technology Refreshment

Maintainability Tasks:
- System Maintenance Concept Definition
- Failure Diagnosis/BIT Requirements
- Maintainability Modeling and Analysis
  - High Level Maintenance and Repair Philosophy
  - Maintainability Requirements Analysis & Allocation
  - Identification of LRUs
- Maintainability Prediction
- Reliability Centered Maintenance
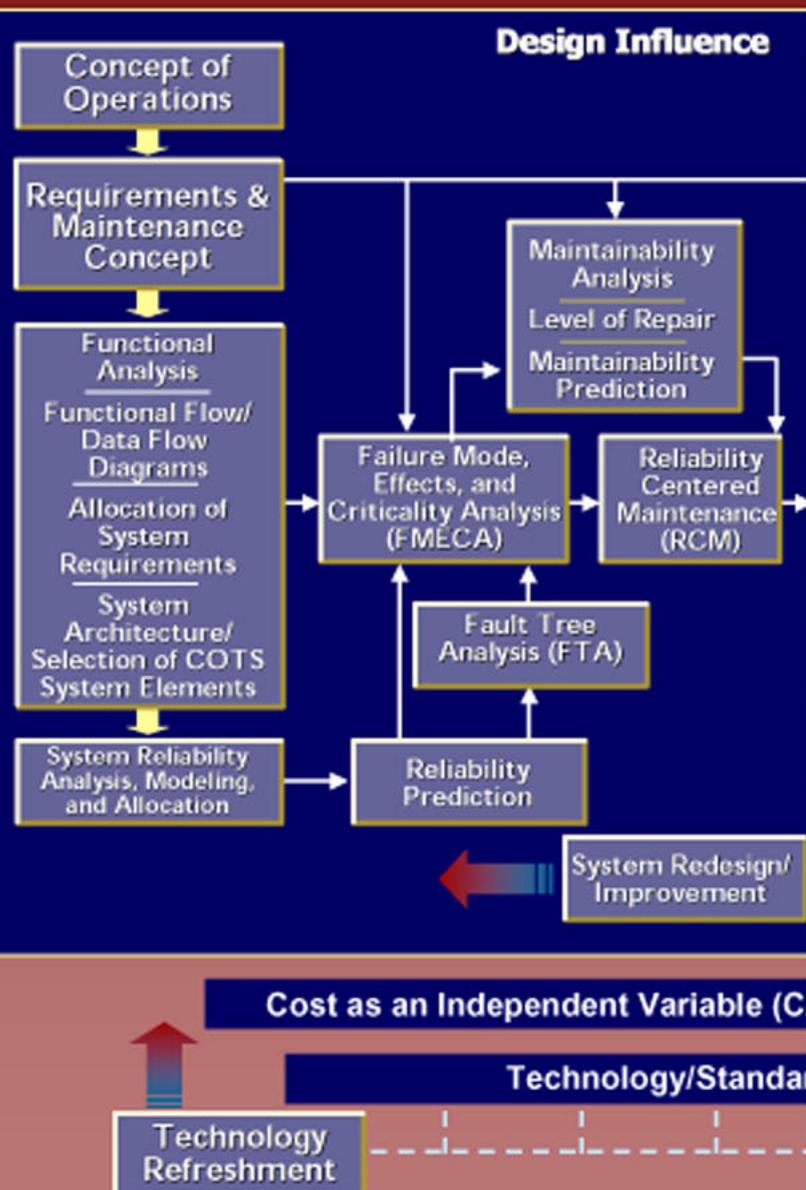- Human Factors/Accessibility Analysis

Reliability

Maintainability ➡

Supportability

- Maintenance Concept
- Accessibility
- Performance Monitoring and Fault Localization
  - Built-In Test Coverage
  - System Modularity/De-Coupling
  - Condition and Usage Monitoring
- Metrics
- Tools

Reliability, Maintainability, and Supportability Engineering Process

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Cost as an Independent Variable (C...

Technology/Standar...

Technology Refreshment

Supportability Tasks:
- Support Concept of Operations
- Analyzing the System From Commonality Perspective
- System Component Interchangeability
- Compliance With Open Systems
- Analysis of HMI vis-à-vis Training (Greater Commonality)
- Analysis of Vendors from Maturity & Stability Perspective
- Technology Analysis From a Proprietary and Maturity Perspective
- Application of Multi-Media Techniques, Information Technology, and Instructional Technology

Reliability

Maintainability

Supportability ➡

- **System Commonality**
  - Physical Commonality
  - Operational Commonality/ HMI Standardization
  - Functional Commonality
- **Standard Parts**
- **Standard Tools/Equipment**
- **Intuitive User Interface**
- **COTS/GOTS Selection and Assessment**
  - Open/Popular System Standards Compliance
  - Multiple Vendors
  - Technology Maturity
- **Metrics**
- **Tools**

System Architecture Development and Supportability Assessment
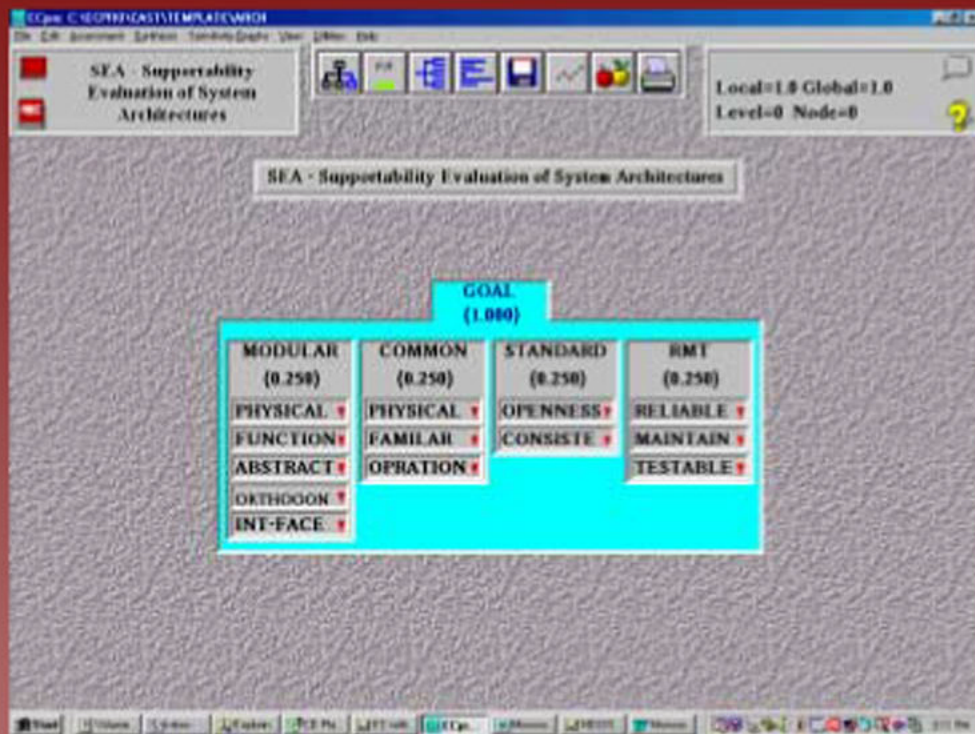
- **Development of Open Standards Compliant Architectures and Architectural Assessment and Evaluation to Ensure**
  - Cost Effective Scalability and Implementation of Future Upgrades and Enhancements
  - Consistent OMI (Operator-Machine I/F) to Enhance Usability and Serviceability
  - Consistent System Management Approach
  - Consistent and Traceable Solution Testing, Validation and Verification Approach

Systems and Supportability Engineering:
Conclusion

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